UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

Date: August 18, 2004

Subject: Results and Analysis of Work
Performed in Deep Monitoring Wells
Fridley Commons Well Field
Fridley, MN
December 2003-January 2004

From: Bob Kay, Geologist
Remedial Response Section #2

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Bob Kay for

To: Sheri Bianchin
Remedial Project Manager

Sheri–as you are aware, Jim and I, in cooperation with Nile Fellows at MPCA and Delta Environmental Consultants, performed some additional investigation in monitoring wells MPCA MW-1, MPCA MW-2, and MPCA MW-3 in the vicinity of the Fridley Commons Well Field Site (the site) in Fridley, MN during December 2003 and January 2004. For the purpose of this memo, wells MPCA MW1, MW2, and MW3 are referred to as wells PDC1, PDC2, and PDC3, respectively (figure 1). Well PDC1 is located about 5,000 feet south of the site and approximately 50 feet north of Fridley Municipal Well #1. Well PDC2 is located approximately 3,500 feet north of the site in Terrace Park. Well PDC3 is located about 6,200 feet southeast of the site on the property of the Grace-Totino High School. These wells were drilled to penetrate most or all of the Prairie du Chien aquifer (table 1), the same aquifer that supplies the contaminated municipal-supply wells at the site. The measuring-point altitude of these wells was taken from topographic maps, and is likely to be within 5 feet of the true altitude. There were three components to the investigation, geophysical logging, water-quality sampling, and water-level measurement.

Wells PDC1, PDC2, and PDC3 were geophysically logged using the equipment of the USEPA Region 5 Technical Support Section over the entire thickness of wells that could be accessed (table 1). We were unable to get the tools below about 132 and 282 ft in wells PDC2 and PDC3, respectively. Rock falling into the borehole has either completely infilled the borehole to these depths, or the borehole has been bridged by rock wedged into the borehole at these depths and is unfilled below. In either event, we were only able to access a small amount of the aquifer in comparison to the drilled depth at wells PDC2 and PDC3 (table 1), reducing the amount of aquifer characterization that could be performed The presence of infilling or bridging indicates the Prairie du Chien is composed of highly weathered, fractured rock.

Natural-gamma logging indicates generally low clay content to the Quaternary, St. Peter Sandstone, and Prairie du Chein deposits (figures 2, 3, 4), with the exception of the elevated clay in the Quaternary deposits in most of the interval between about 143 and 168 ft (732 and 757 feet above sea level (fasl)) and in well PDC1, a slight elevation in clay content between about 232 and 275 ft (668 and 695 fasl) in well MW3, and a increase in clay content in the upper part of the Prairie du Chein at about 124 ft (740 fasl) in well MW2. The lithologic and geophysical logs generally are consistent and indicate the Quaternary deposits are primarily sand and gravel, with clay layers interspersed. Lithologic and geophysical logs indicate that the St. Peter Sandstone and Prairie du Chein deposits tend to have small amounts of clay in the rock matrix. This data is insufficient for stratigraphic interpretation, but studies elsewhere in southeastern Minnesota have determined that the middle and upper parts of the Prairie du Chien deposits tend to be highly permeable, whereas the lower part is less permeable (Runkel and Tipping, 2002).

Caliper logging performed in well PDC1 indicates the presence of fractures throughout the entire thickness of the Prairie du Chien deposits penetrated by this well (fig. 2). Particularly large fractures, about 10 inches, were indicated near the top of the deposits at about 172 ft (727 fasl) and at the bottom of the borehole at about 233 ft (666 fasl). Caliper logging indicated the presence of large fractures at about 131 and 133 ft (about 827 and 829 fasl) in well PDC2 (fig. 3) and at 283 ft (about 733 fasl) in well PDC3 (fig. 4). However, these apparent fractures may just be washouts beneath the casings. The caliper-log data is indicative of highly weathered and fractured rock. The fractures near the top of the deposit likely reflect the presence of weathering features near the bedrock surface. The depth of the fractures does not correspond to high natural-gamma counts, indicating the fractures are not infilled with clays.

We originally intended to perform acoustic televiewer logging to identify the location and orientation of fractures, vugs, and solution openings in the aquifer indicated by the caliper logs. However, infilling of wells PDC2 and PDC3 prevented televiewer logging these wells and concerns about tool safety prevented televiewer logging well PDC3.

Fluid temperature, conductivity, and other water-quality logs obtained in well PDC1 indicate water movement associated with the fracture at 172 ft (728 fasl)(figs. 2, 5). A second temperature log collected while logging this hole for general water-quality parameters indicates water movement associated with potential fractures at about 184 ft (716 fasl) in this well, but that reading is not confirmed by other logs. Temperature logs also indicate water movement immediately below the bottom of the casing at about 122 ft (722 fasl) in well PDC2 (figs. 3, 6) and at the fracture at 283 ft (960 fasl) in well PDC3 (figs. 4, 7).

Flowmeter logging was done in well PDC1 to identify the location of the fractures, vugs, and solution openings that area transmitting water through the aquifer (the hydraulically active features). We took three sets of readings, which showed different values for amount of flow and direction of flow between runs (table 2, fig. 2). These results indicate that hydraulically active features are present over the entire length of the borehole and that pumping from offsite wells was affecting flow within the aquifer.

Water-quality samples were collected at well PCD2 in the middle of the open interval at a depth 129 feet and at well PDC3 in the middle of the open interval at a depth of 284 feet. Given the small open intervals of these wells, only one sample could be collected . Water-quality samples were collected from well PDC1 at depths of 175, 190, 200, 212, and 226 feet. These intervals were chosen to sample water coming in or going out from each of the hydraulically active intervals identified in this well by the flowmeter logging. Each of these samples was collected by use of a "thief" sampler and analyzed for VOCs by use of method 468. Samples were collected, preserved, labeled, stored, transported, and analyzed in accordance with the approved Sampling and Analysis Plan for the site (Delta Environmental Consultants, 2002), as amended. Analysis of the QAQC data indicates the results were acceptable for use. The only VOC detected in an investigative sample was chloroform at 0.4 ug/L in the sample collected at 175 feet in well PDC1. Chloroform also was detected in the method blank at a concentration of 0.2 ug/L and it is assumed the detection in well PDC1 was not representative of water quality in the aquifer. The absence of VOCs in the sample results indicates that these compounds are not present in the Prairie du Chien aquifer at PDC1, and are not present in the upper part of the aquifer at PDC2 and PDC3. The presence or absence of VOCs in the deeper part of the aquifer at wells PDC2 and PDC3 cannot be determined because the wells have been infilled. It should be pointed out that there have been historical detections of TCE in the Prairie du Chien aquifer in and near well PDC3 (Barr Engineering, 1997), indicating that there is or was a source hydraulically upgradient of this well.

Water-level data was collected by Delta in wells PDC1 and PDC2 from December 12, 2003 through January 18, 2004. Water-level data was collected from well PDC3 from December 30, 2003 through January 18, 2004. Water levels were measured at a 15 minute sampling frequency with a 0-10 psi pressure transducer and recorded by use of a datalogger. The dataloggers were programmed to measure water levels essentially simultaneously in each well. Information on pumping schedules from the Fridley municipal wells during this time period also were determined. According to the records, Fridley Municipal wells 4, 5, and 6 were the only wells pumped during the monitoring period (other data indicates that some of the other municipal wells also may have been pumped, but that information has not been verified). Of these wells, only well 6 draws water from the Prairie du Chein deposits. The Fridley wells typically were pumped for a period of about 45 minutes at a time, several times a day.

Water levels in wells PDC1 and PDC2 showed a clear response to pumping in the Fridley Municipal well 6 (figs. 8, 9, 10, 11). Water levels in well PDC3 do not appear to respond to pumping in the Fridley Municipal wells (figs. 12,13), but do appear to respond to either changes in barometric pressure or pumping from some other, unidentified municipal wells–the municipal wells at New Brighton being the most likely candidates. Water-level change in well PDC2 in response to pumping typically was about 1.0-1.5 ft after about 45 minutes of pumping (the approximate typical duration of pumping in the municipal wells). Water-level change in well PDC1 in response to pumping was typically about 0.10-0.20 ft over the same period. These changes are not large enough to alter the direction of flow in the aquifer. The magnitude of drawdown (water level change due to pumping) decreases with increasing distance from the pumped well and shows fairly similar values when normalized for distance. This drawdown distribution indicates that the Prairie du Chien may function as an isotropic aquifer at this scale of investigation.

Static water-level data collected on December 12, 2003 (table 1) indicate flow in the aquifer was from north to south, with some westerly component. This direction is roughly consistent with the direction determined from water-level measurements taken shortly after these wells were drilled in 1994 (table 1), although based solely on the data from well PDC3, there may have been a somewhat more north-south component of flow through the aquifer in 2004 and a slightly greater east-west component of flow in 1994.

The geophysical, chemical, and hydraulic data do not indicate a source for the contamination in Fridley Municipal wells. However, the results of this investigation tend to indicate that the aquifer functions as a homogenous and isotropic aquifer at the scale of investigation and a source located in the upgradient direction of ground-water flow (east-northeast) may be indicated. There are a couple of "quick and dirty" additional avenues of investigation that might shed some light on the potential location of a source area.

A. It appears that the water quality in the Fridley Municipal wells has improved substantially in recent months, following a trend of more gradual improvement during the past several years. One possible explanation for this improvement may be related to a shift in the direction of ground-water flow in the aquifer, potentially indicated by the most recent water-level data from wells PDC1, PDC2, and PDC3. The evidence for a shift in the water-level data is thin, but it may be worthwhile to have Delta perform a round of water-level measurements from area monitoring wells to determine if flow direction has in fact changed, or if what we may have been seeing in the December 2003 data was some artifact of well construction or the very small data set. It also might be worthwhile to check the stage of the Mississippi River and pumping volumes for the high capacity water-supply wells in the area to see if there have been any changes in hydraulic conditions that could induce any potential change in flow direction. If a shift in flow direction can be verified, it would tend to refine the areas where the source area could, and could not, be. If there is no demonstrable shift in flow direction, that information would tend to indicate that the improvement in water quality at the municipal wells is the result of the plume being remediated by natural attenuation processes rather than a shift in it's location.

B. Now that we can somewhat confidently assume the Prairie du Chien acts as a homogenous, isotropic aquifer a capture-zone analysis of the Fridley Municipal wells also could point toward a source area.

There is no smoking gun here, but the data we've collected indicates that the source area is not southwest of the well field, but would more likely be north or east of the well field. This interpretation is consistent with historical directions of ground-water flow, the historical presence of TCE in a Prairie du Chien monitoring well west of the well field (MPCA 3 according to Barr Engineering, 1997, fig. 3-1) and the fact that the Fridley wells with the highest levels of contamination are in the southern and eastern parts of the well field.

Feel free to call me at 6-7938 of Jim at 3-1526 if you have any questions or comments.

cc. S. Padavoni
S. Ostrodca
N. Fellows, MPCA
U.S. Geological Survey, MN District
Delta Environmental

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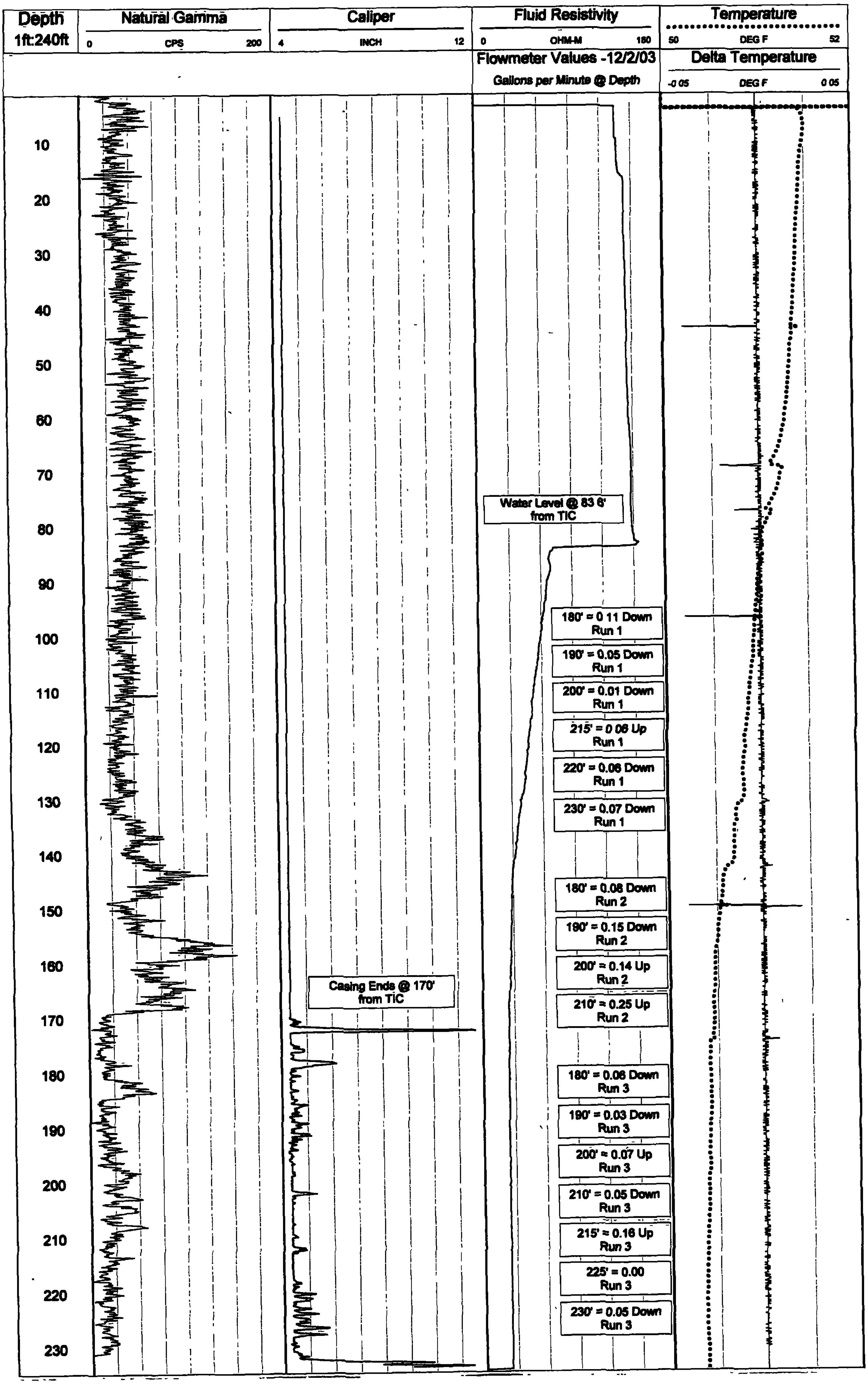

Figure 2. Geophysical logs, well PDC1, Fridley Commons Wells Field site, Fridley, MN.

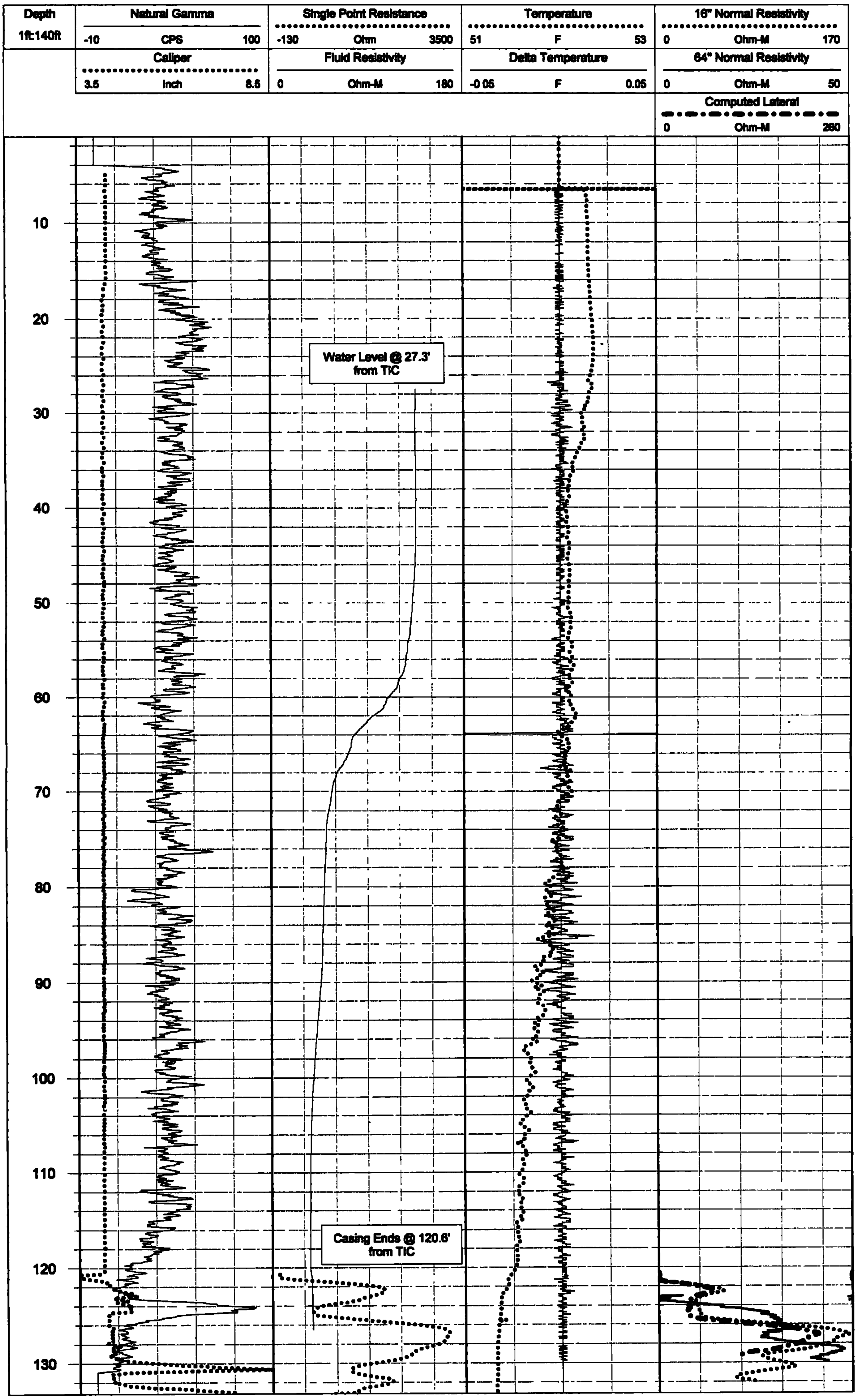

Figure 3. Geophysical logs, well PDC2, Fridley Commons Wells Field site, Fridley, MN.

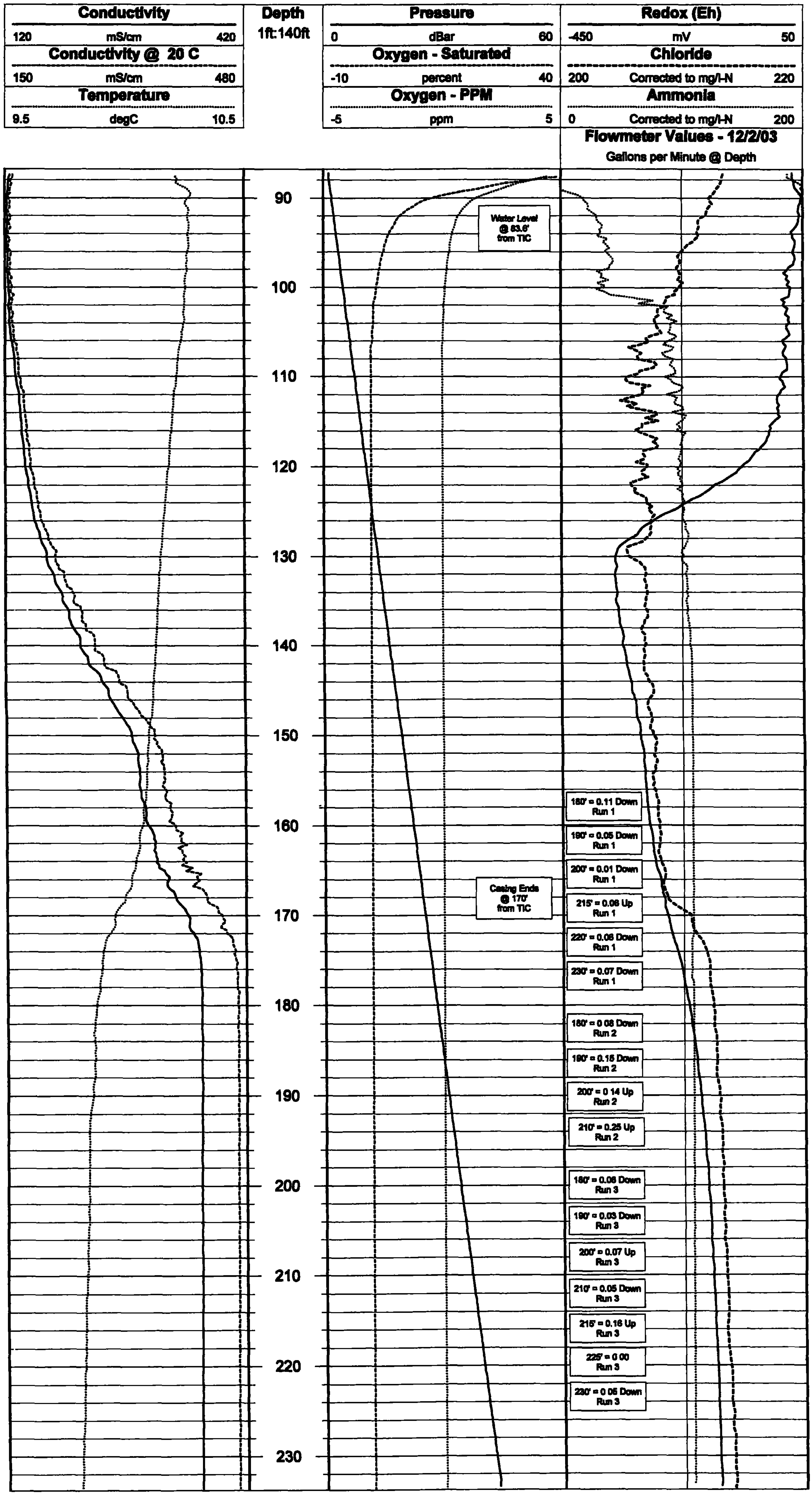

Figure 5. Water-quality parameter logs, well PDC1, Fridley Commons Wells Field site, Fridley, MN.

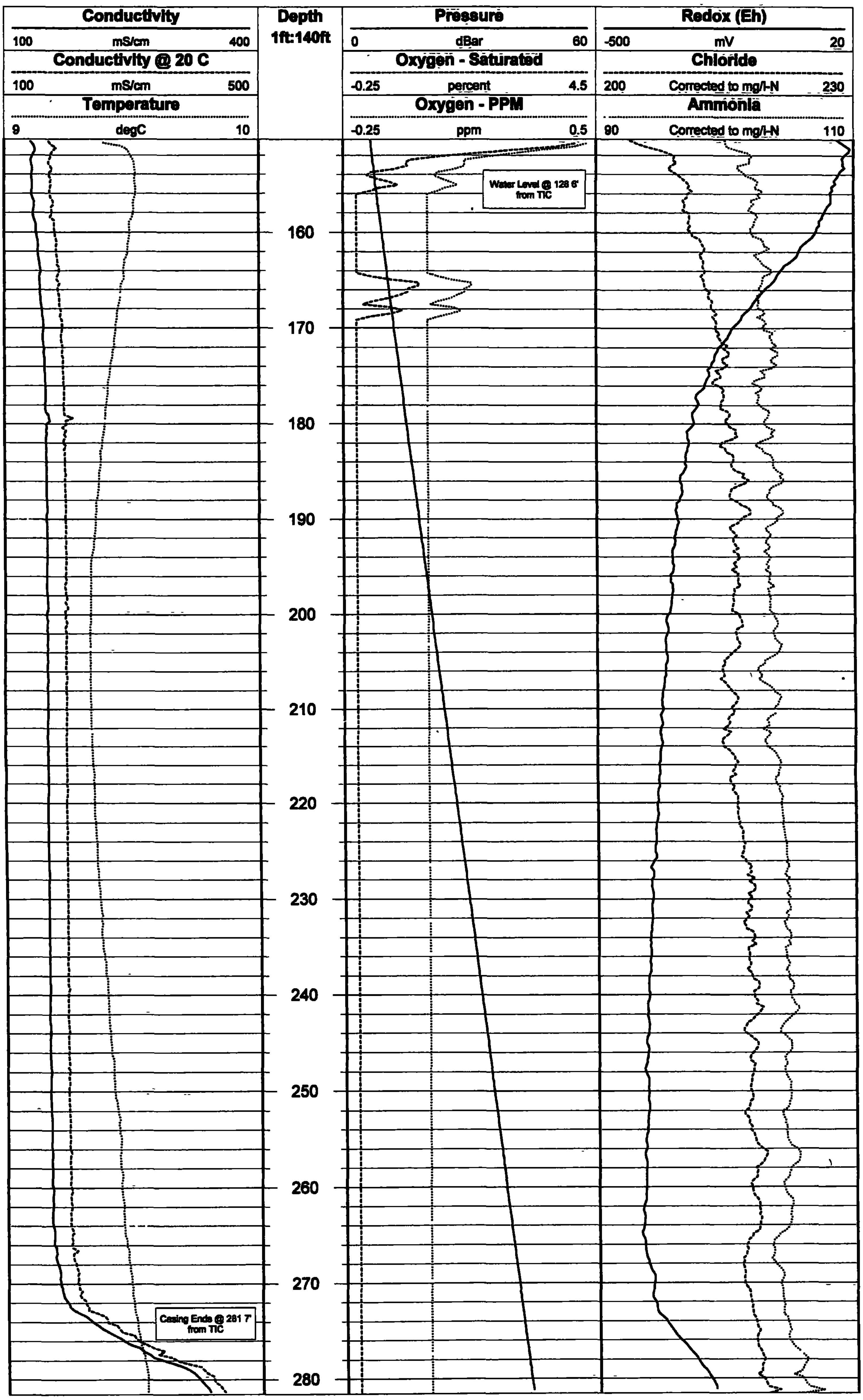

Figure 7. Water-quality parameter logs, well PDC3, Fridley Commons Wells Field site, Fridley, MN.

Figure 8. Water-levels in well PDC1, January 1 and 2, 2004, Fridley MN.

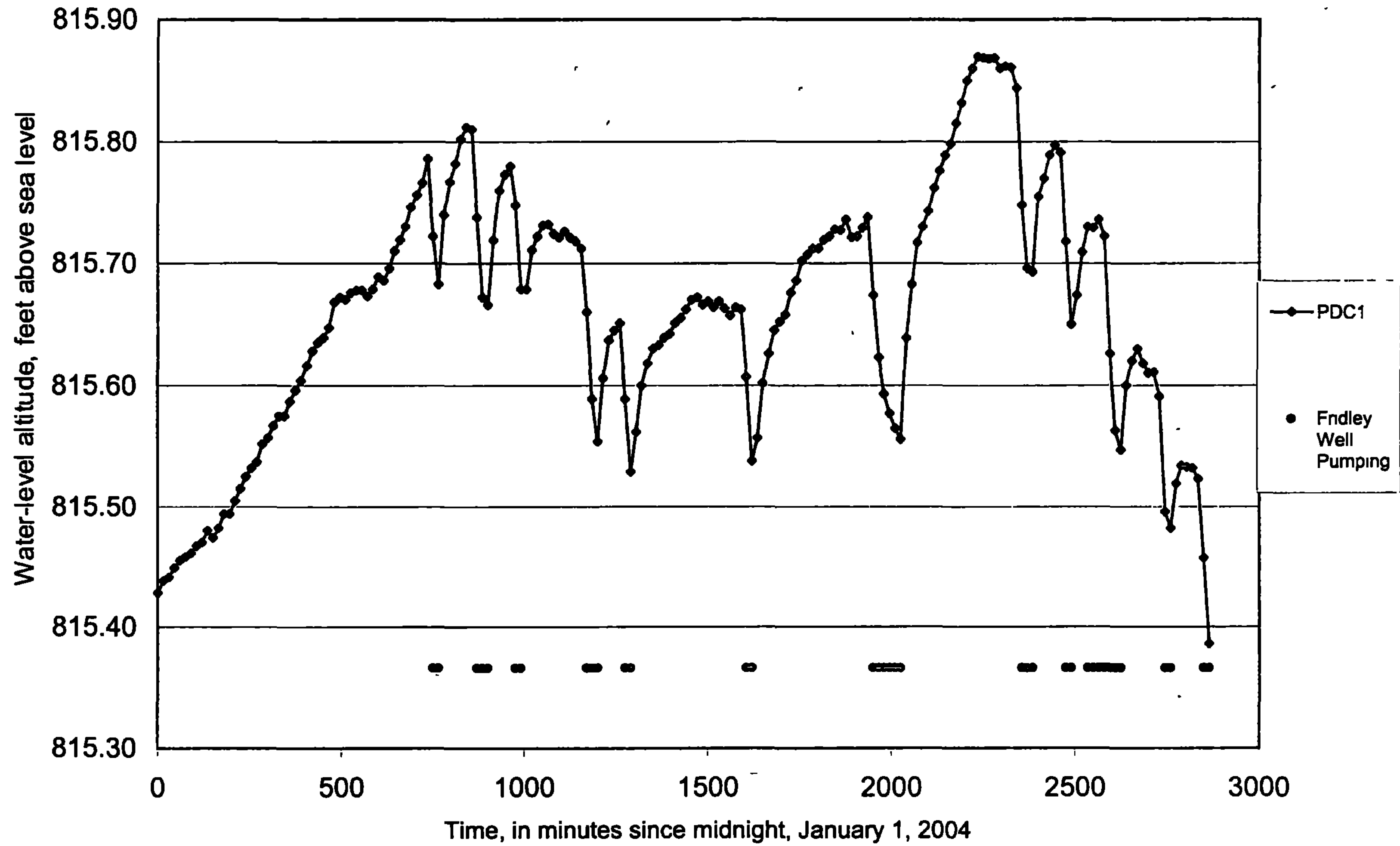

Figure 9. Water level in well PDC1, January 5, 2004, Fridley, MN

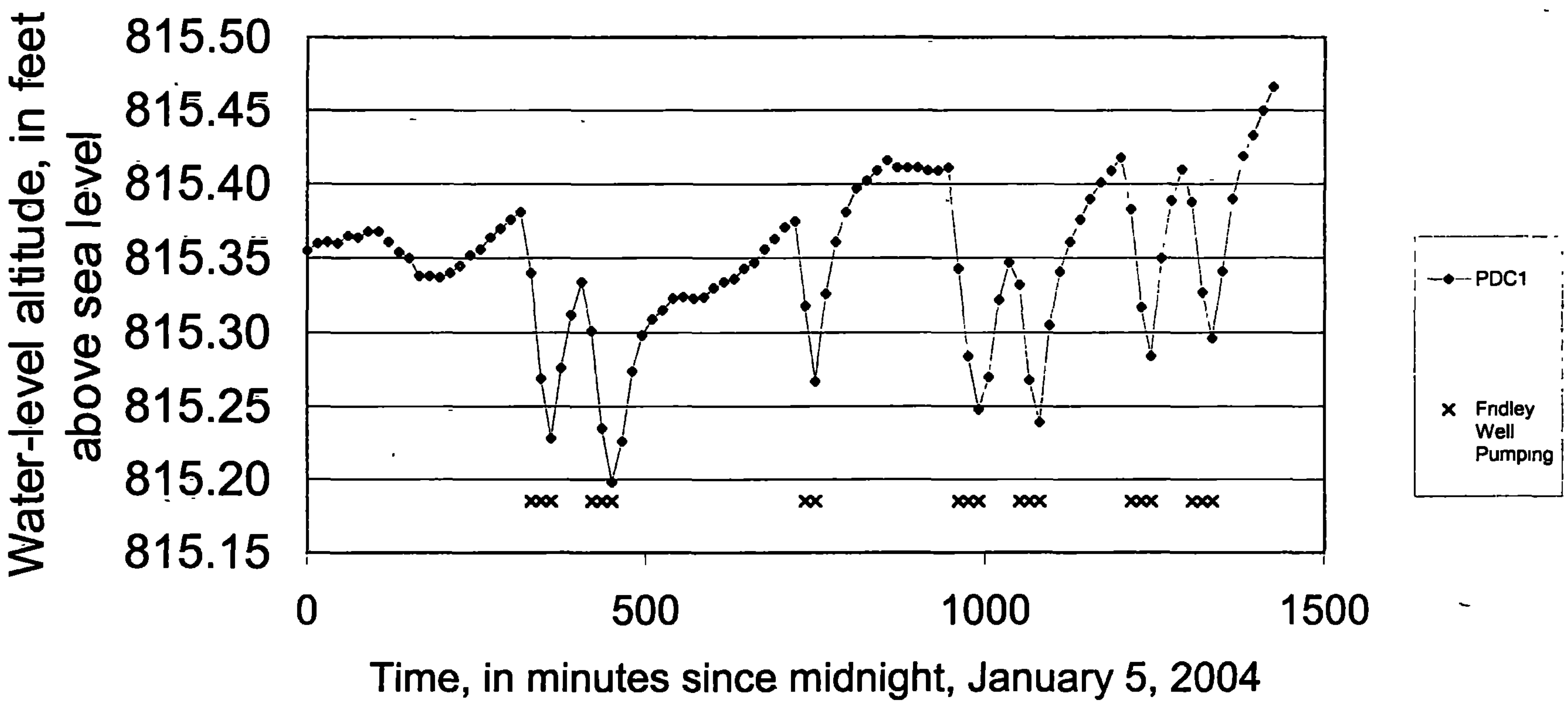

Figure. 10. Water-levels in well PDC2, January 1 and 2, 2004, Fridley MN.

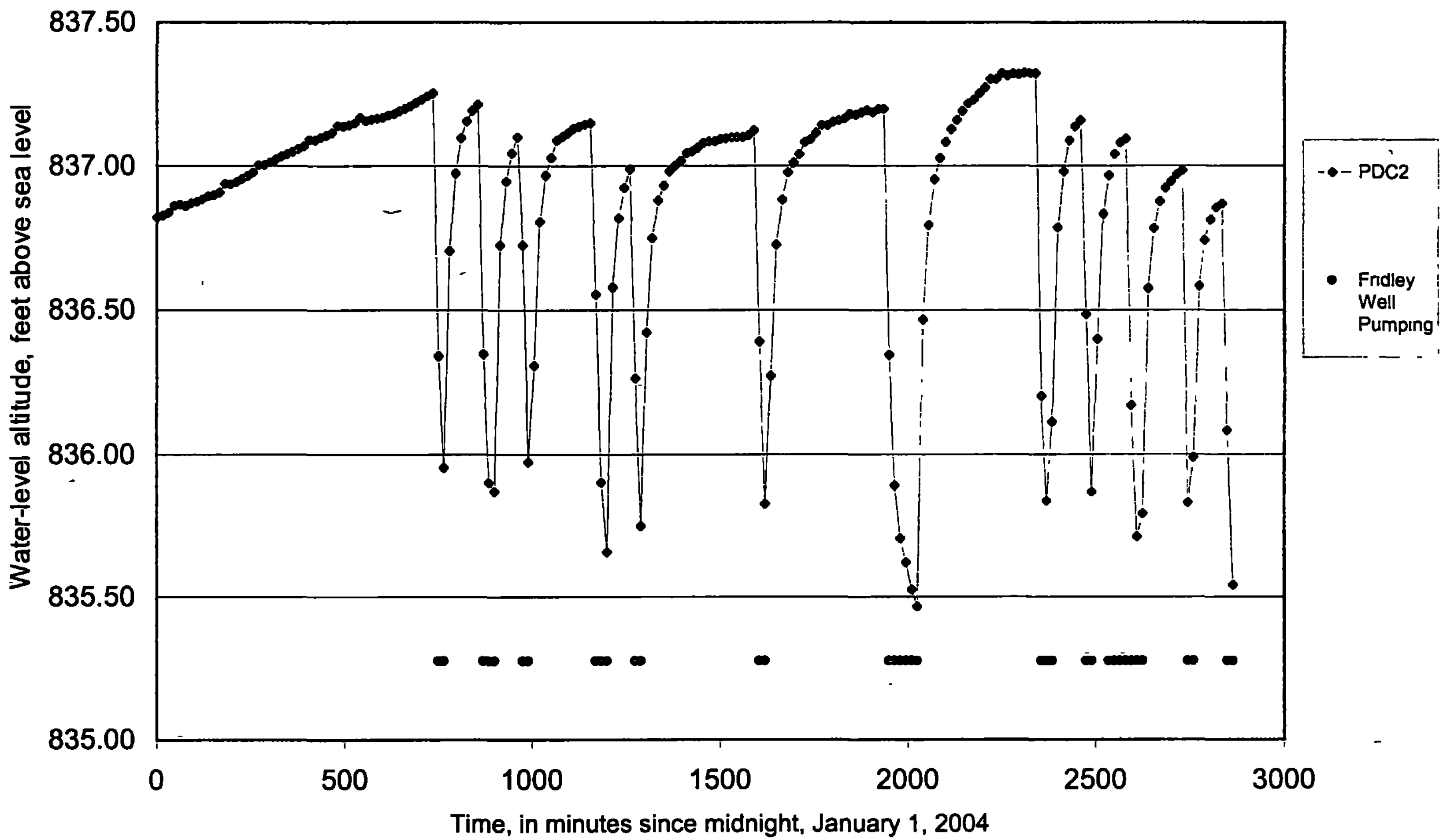

Figure 11: Water level in well PDC2, January 5, 2004, Fridley, MN

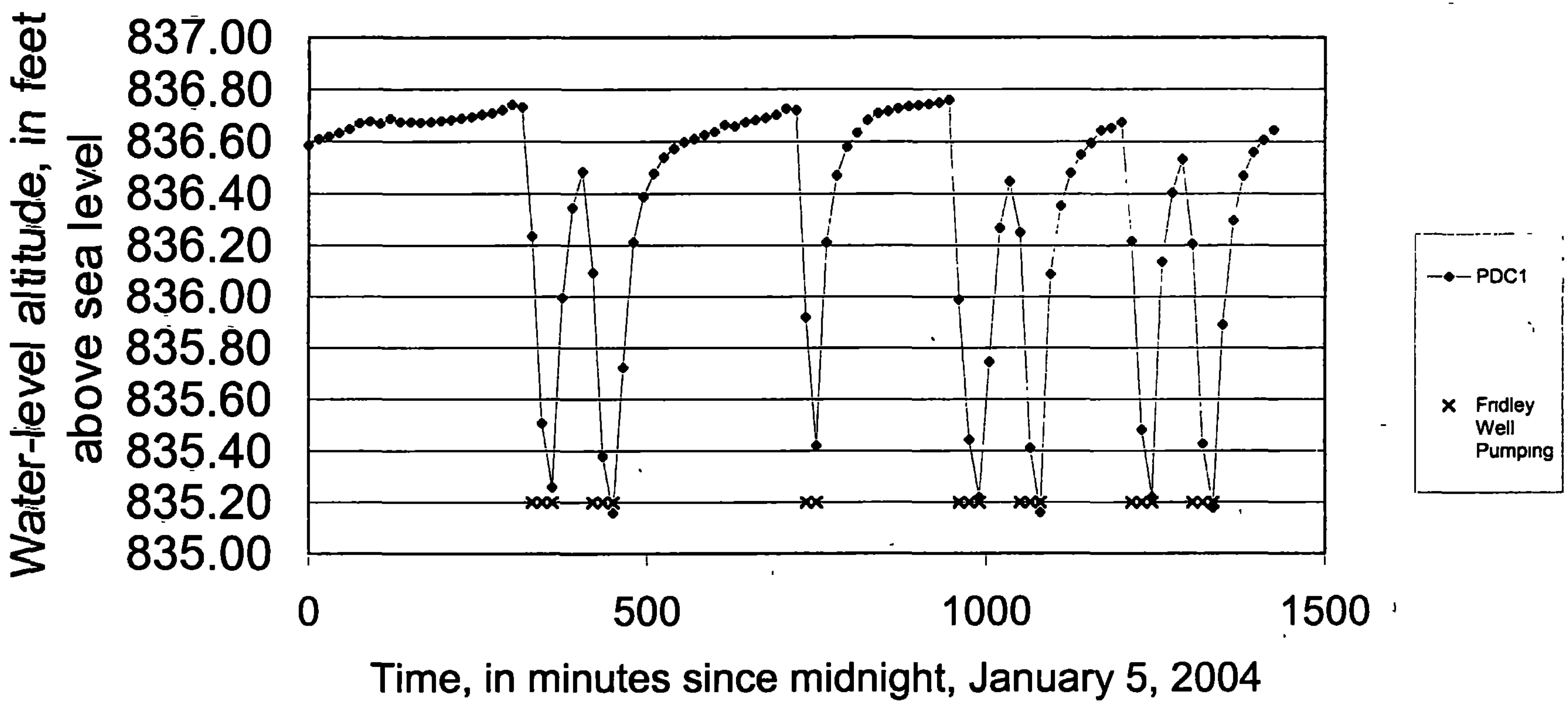

Figure 12. Water-levels in well PDC3, January 1 and 2, 2004, Fridley MN.

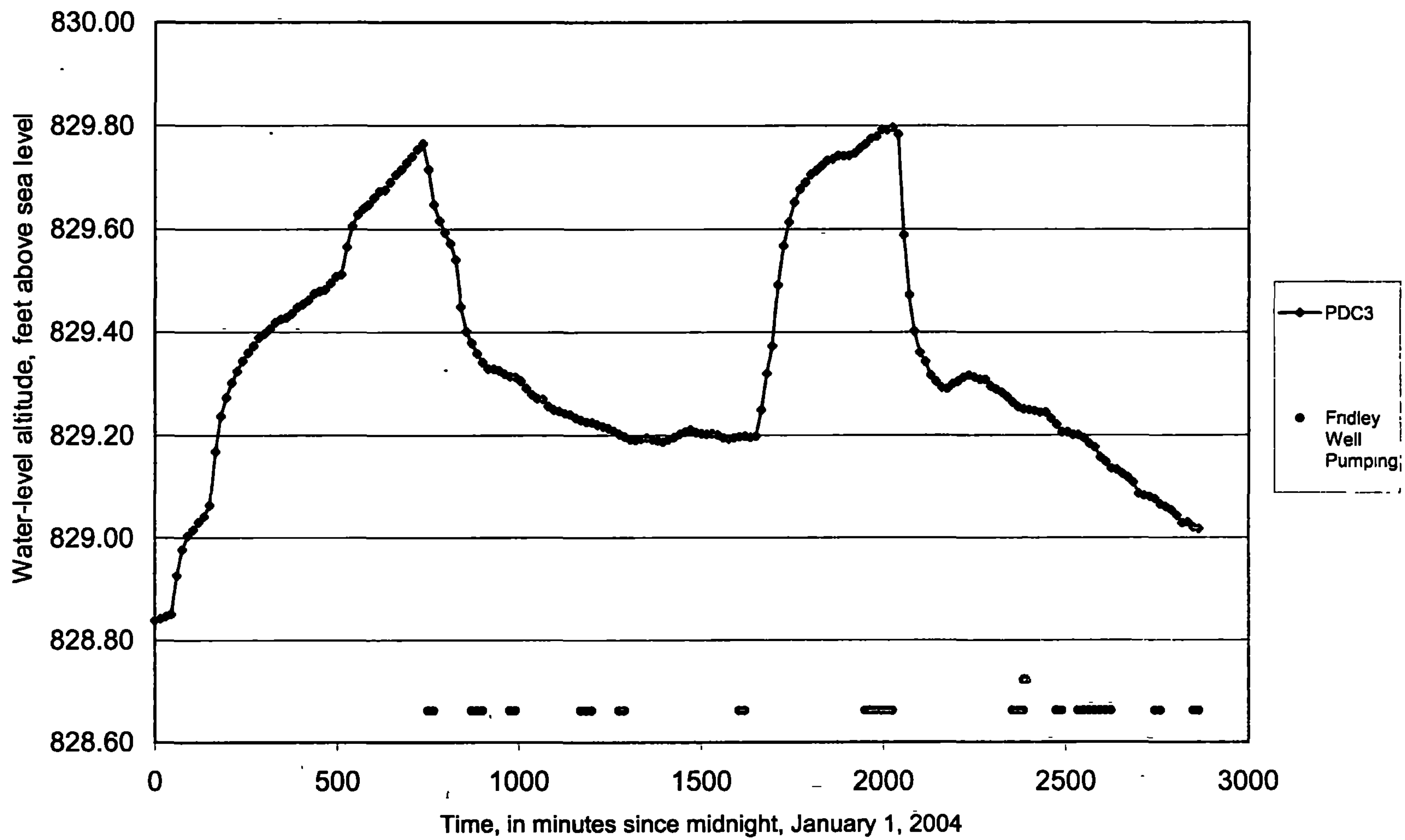

Figure 13. Water level in well PDC3, January 5, 2004, Fridley, MN

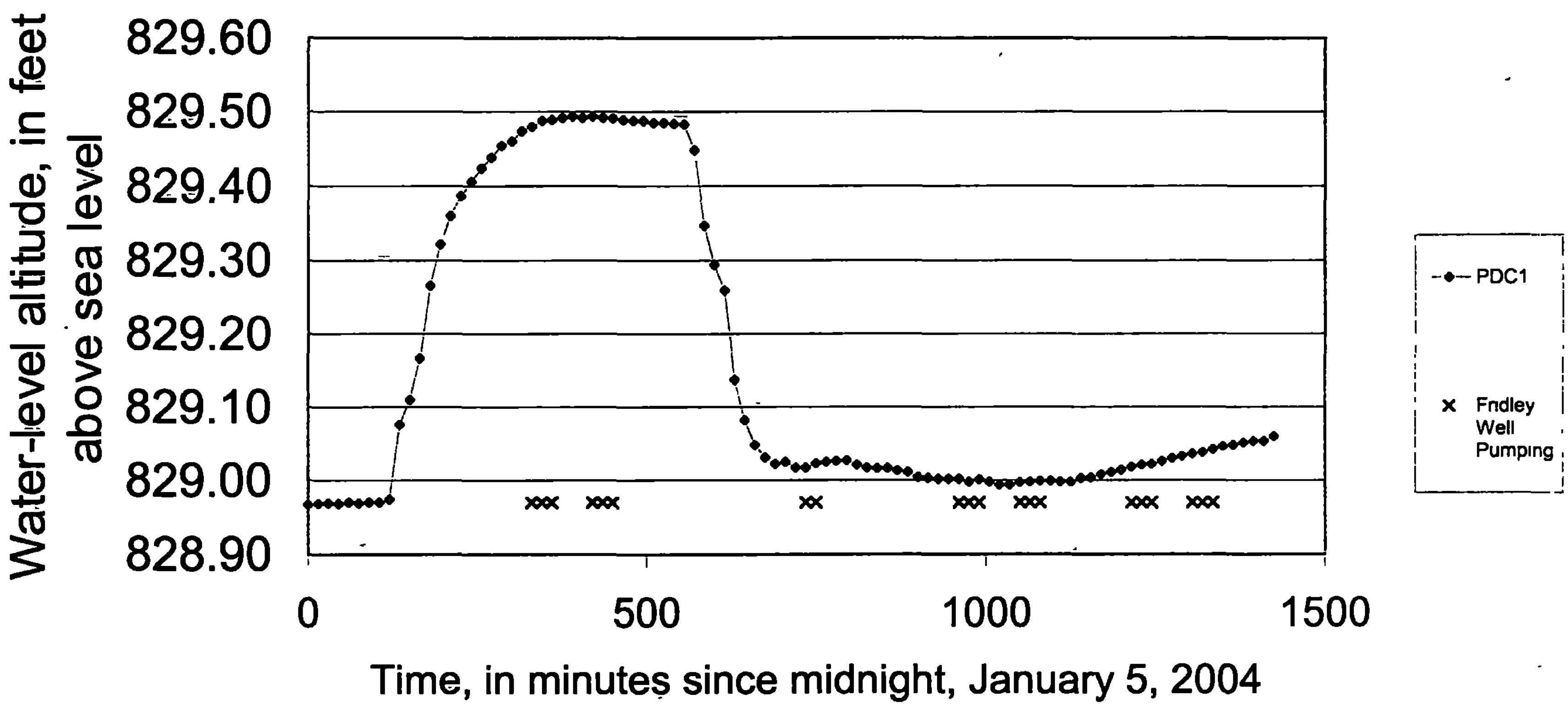

Table 1. Well information, PDC1, PDC2, PDC3, Fridley Commons Well Field Site, Fridley, MN.

Name	Altitude of Top of Well Casing	Water-Level Altitude 9/08/94	Water-Level Altitude 12/12/03	Depth of well casing	Depth of well when drilled	Altitude of bottom of well casing[1]	Altitude of bottom of well when drilled	Depth of Well 9/94	Depth of Well 12/03	Altitude of bottom of well 12/03
	(feet above sea level)	(feet above sea level)	(feet above sea level)	(feet below land surface)	(feet below land surface)	(feet above sea level)	(feet above sea level)	(feet below land surface)	(feet below land surface)	(feet above sea level)
PDC1	900	815	815.46	164	299	736	601	237	237	663
PDC2	864	837	836.90	121	218	743	646	?	132	732
PDC3	960	832	828.75	283	357	677	603	284	282	678

[1]Top of Prairie du Chien deposit typically about 5 feet below bottom of well casing

Table 2. Flowmeter results for well PDC1, 12/2/03				
	Flowmeter value			
Depth of measurement	Run 1	Run 2	Run 3	
(feet)	(gallons per minute)			
180	.11D	.08D	.06D	
190	05D	15D	.03D	
200	.01D	.14U	.07U	
210	NM	.25U	.05D	
215	06U	NM	.16U	
220	.06D	NM	NM	
225	NM	NM	0.00	
230	.07D	NM	.05D	
U-upward flow				
D-Downward flow				
NM-not measured				